20th Annual Ground Vehicle Survivability Symposium

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Active Protection System Compliance Plan

Will Norton and Shannon Durbin
TARDEC Hit Avoidance Development and Integration Team
Warren, MI
19 AUG 2010

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
19 AUG 2010	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Active Protection system Compliance Plan	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Will Norton Shannon Durbin	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA	**21064**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	TACOM/TARDEC
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
	21064

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

Presented at NDIAs Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), 17 22 August 2009,Troy, Michigan, USA, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**13**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Agenda

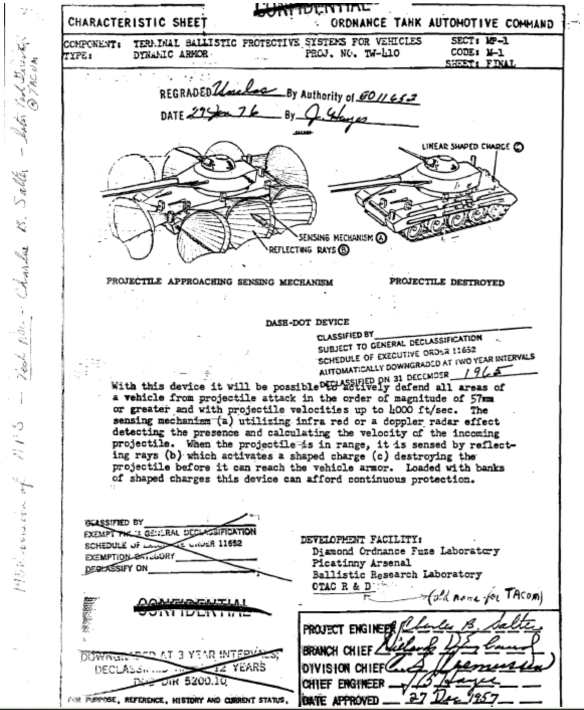
- History of Active Protection
- Current Situation
- Compliance Plan Overview
- Attributes
- Program Structure
- Configuration Management
- Decision Process
- Implementation
- SIL Validation
- Example Tasks
- Questions/Feedback

RDECOM

History of Active Protection

TARDEC

If you need a machine and don't buy it, then you will ultimately find that you have paid for it, but don't have it. - Henry Ford


CONFIDENTIAL

CHARACTERISTIC SHEET — ORDNANCE TANK AUTOMOTIVE COMMAND

COMPONENT: TERMINAL BALLISTIC PROTECTIVE SYSTEMS FOR VEHICLES — SECT: MP-1
TYPE: DYNAMIC ARMOR — PROJ. NO. TW-410 — CODE: M-1 — SHEET: FINAL

REGRADED Unclas By Authority of EO 11652
DATE 29 Jan 76 By J. Hayes

LINEAR SHAPED CHARGE (C)
SENSING MECHANISM (A)
REFLECTING RAYS (B)

PROJECTILE APPROACHING SENSING MECHANISM — PROJECTILE DESTROYED

DASH-DOT DEVICE

CLASSIFIED BY
SUBJECT TO GENERAL DECLASSIFICATION
SCHEDULE OF EXECUTIVE ORDER 11652
AUTOMATICALLY DOWNGRADED AT TWO YEAR INTERVALS
DECLASSIFIED ON 31 DECEMBER 1965

With this device it will be possible to actively defend all areas of a vehicle from projectile attack in the order of magnitude of 57mm or greater and with projectile velocities up to 4000 ft/sec. The sensing mechanism (a) utilizing infra red or a doppler radar effect detecting the presence and calculating the velocity of the incoming projectile. When the projectile is in range, it is sensed by reflecting rays (b) which activates a shaped charge (c) destroying the projectile before it can reach the vehicle armor. Loaded with banks of shaped charges this device can afford continuous protection.

CLASSIFIED BY
EXEMPT FROM GENERAL DECLASSIFICATION
SCHEDULE OF EXECUTIVE ORDER 11652
EXEMPTION CATEGORY
DECLASSIFY ON

DEVELOPMENT FACILITY:
Diamond Ordnance Fuze Laboratory
Picatinny Arsenal
Ballistic Research Laboratory
OTAC R & D (old name for TACOM)

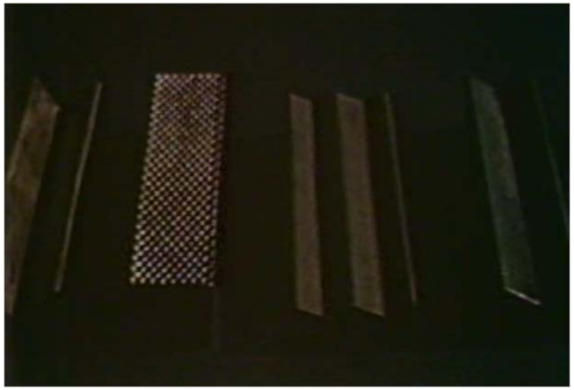
CONFIDENTIAL

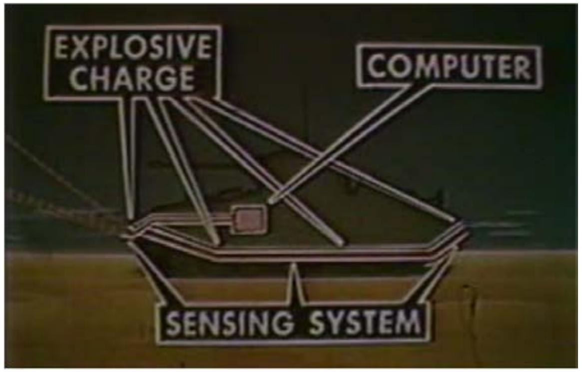
DOWNGRADED AT 3 YEAR INTERVALS; DECLASSIFIED AFTER 12 YEARS
DOD DIR 5200.10

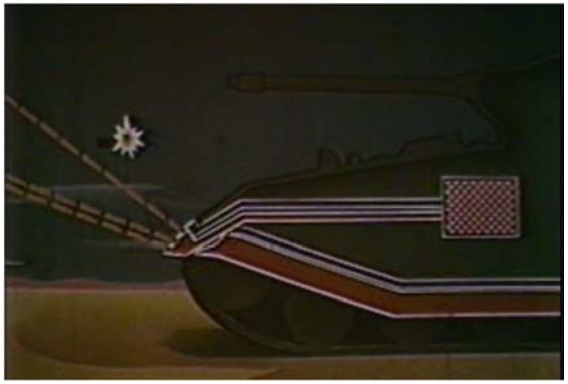
FOR PURPOSE, REFERENCE, HISTORY AND CURRENT STATUS,

PROJECT ENGINEER Charles B. Salter
BRANCH CHIEF
DIVISION CHIEF
CHIEF ENGINEER
DATE APPROVED 27 Dec 1957

BLUF – Hard to develop a material solution without requirements and logical process to follow.

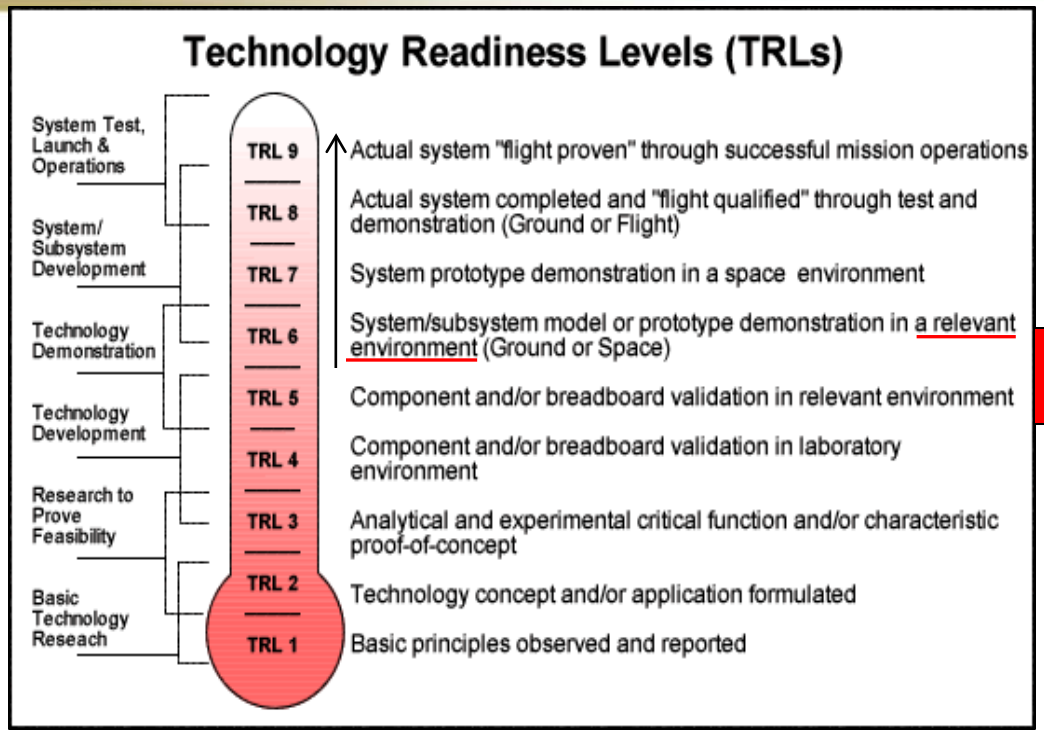




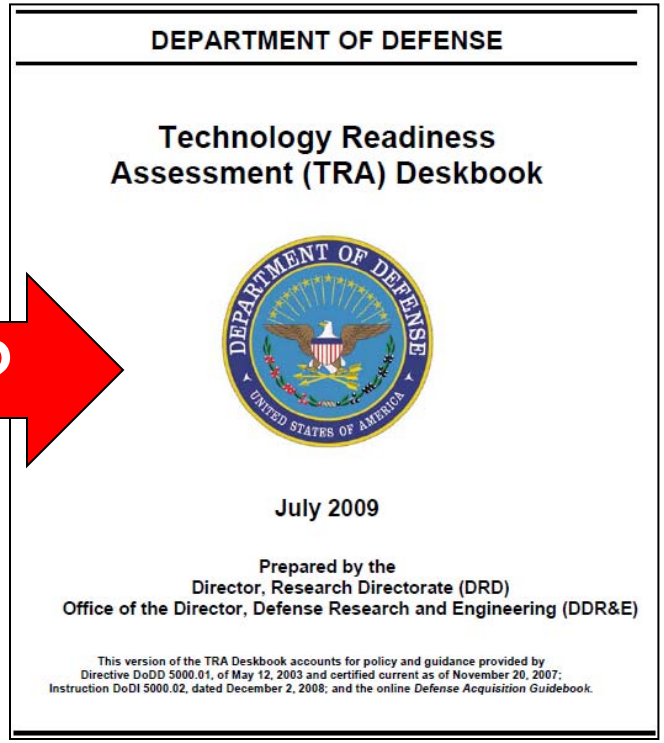


DAMI_TARDEC_GSS_AP.C@conus.army.mil

Current Situation



?



DEPARTMENT OF DEFENSE

Technology Readiness Assessment (TRA) Deskbook

July 2009

Prepared by the
Director, Research Directorate (DRD)
Office of the Director, Defense Research and Engineering (DDR&E)

This version of the TRA Deskbook accounts for policy and guidance provided by Directive DoDD 5000.01, of May 12, 2003 and certified current as of November 20, 2007; Instruction DoDI 5000.02, dated December 2, 2008; and the online *Defense Acquisition Guidebook*.

PM's want:

TRL 6 or higher
Maturation of Existing Technologies
No major redesign activity (Major design activities complete)
Well understood systems (Performance, limitations, reliability, O&S)

"As an activity separate from the formal TRA, an early evaluation of technology maturity conducted shortly before Milestone A should be used to support the development of the Technology Development Strategy (TDS)."

"The law allows the MDA to waive the certification requirement (i.e., the technology in the program has been demonstrated in a relevant environment) if it determines that such a requirement would hinder the DoD's ability to meet critical national security objectives. As a matter of practice, such waivers will be granted only in extraordinary circumstances.7"

Compliance Plan Overview

- (U) Compliance Plan Objectives
  - Estimate TRL of a specific system to a common standard
  - Verify TRL compliance to PMs interested in transition
  - Determine if the APS is mature enough to start a compliance effort
  - Establish specific tasks required to achieve each TRL milestone with respect to APS technologies as a function of gate review
- (U) The compliance plan uses specified requirements to measure and evaluate the maturity of:
  - Systems
  - Subsystems
  - Components
  - Software

Attributes

- (U) IS:
  - Detailed process to determine technical maturity
  - Comprehensive effort including government activities required to assure the APS works correctly/meets requirements for transition
  - Living document customized for each specific APS technology compliance program
  - Significant DoD investment each time it is exercised and the first time will be the most costly
- (U) IS NOT:
  - A developmental (R&D) effort
  - A program of record

Program Structure

1.1 ATO-R
1.2 ATO-D
1.3 Non-ATO Projects
1.4 SIBR Project
1.5 Congressional Project

PM Requirements

APS Compliance Plan

TRL 4 — Design to PM Requirements

Component Validation through Test / Analysis / Similarity — TRL 5

Functional System in a Relevant Environment Meeting Customer Requirements — TRL 6

PM Risk Assessment/Reduction Activity

All steps may not be required, based on PM's risk tolerance

Transition ?

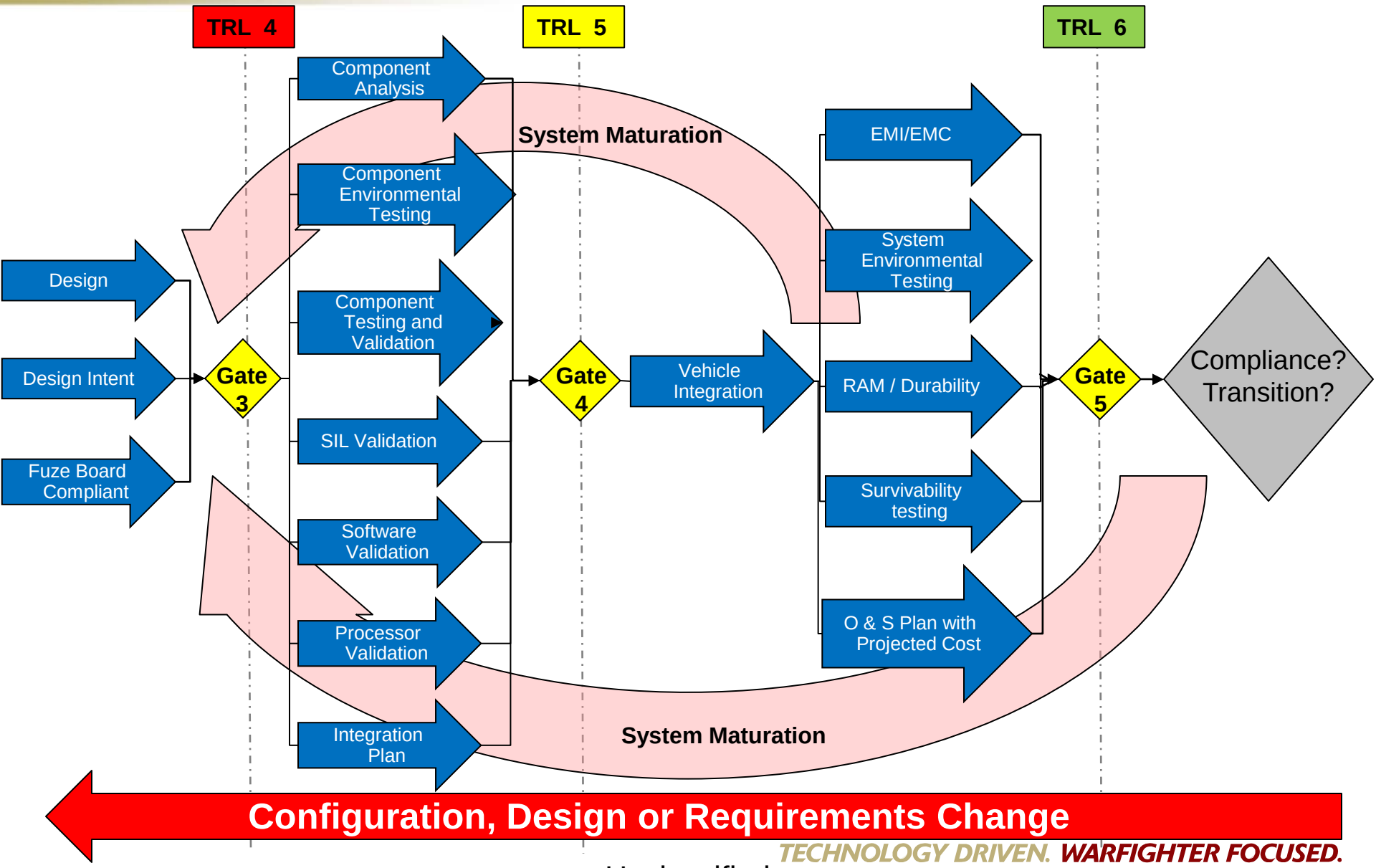
AoA

2.1 Material Solution Analysis Phase
2.2 Technology Development Phase
2.3 Engineering & Manufacturing Development Phase
2.4 Production and Deployment Phase
2.5 **Operations and Support**

Configuration Management

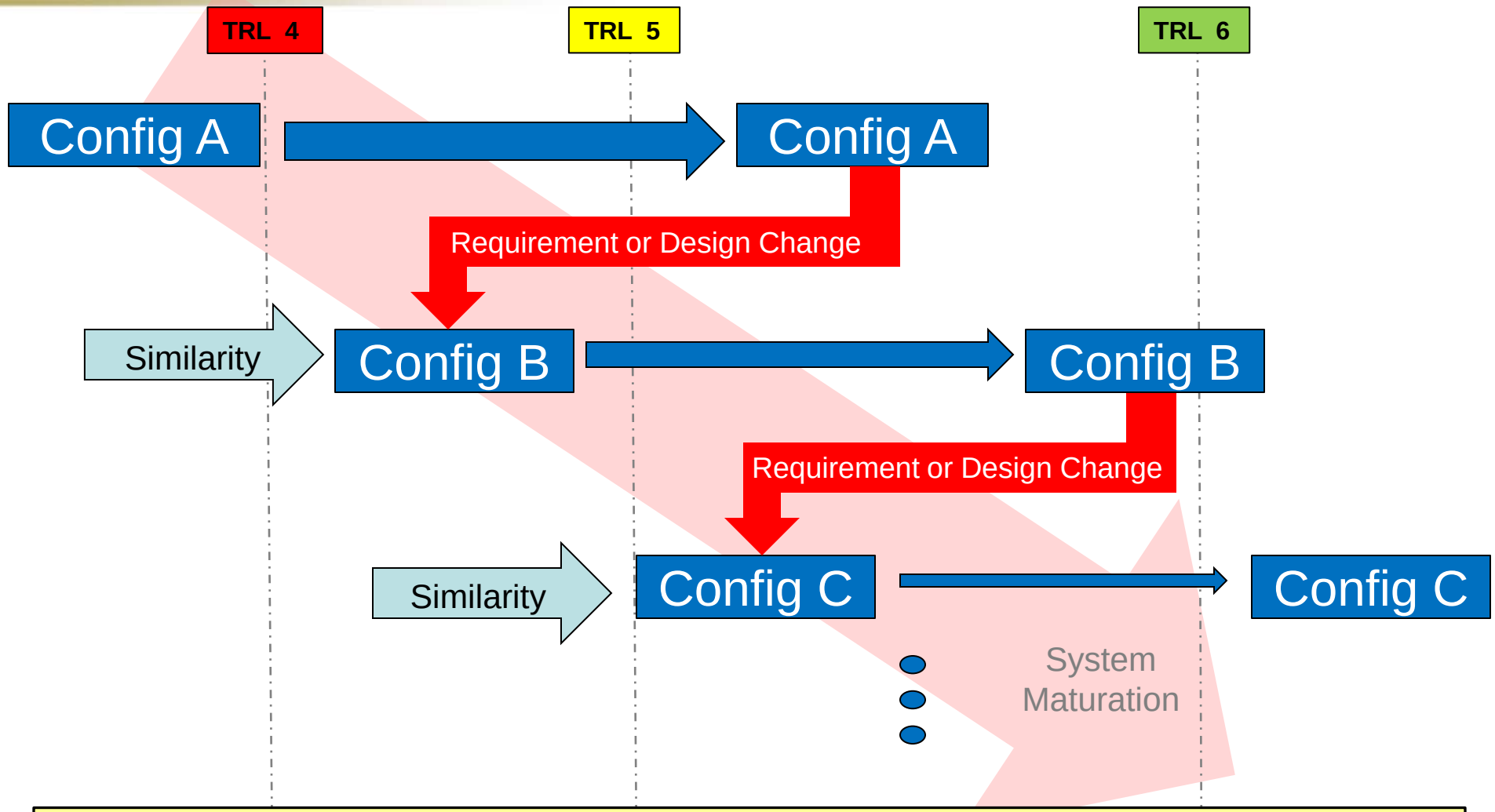
- (U) Compliance plans are assigned to specific APS configurations (hardware or software).
  - Possible to have different configurations at different TRLs.
- (U) If design changes are deemed necessary during the assessment a new compliance plan request is submitted.
  - Some elements may be accepted based on similarity but each element will be re-evaluated.
- (U) The compliance plan and requirements are living documents and anticipated to be configuration managed as well.

Decision Process



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Implementation



PM could integrate any configuration, depending on acceptable performance risk

SIL Validation

- (U) Software/Hardware-in-the-Loop Testing

- (U) Unit Testing
  - Test functions/classes within software to verify requirements are met
  - Physical space requirements, I/O pins/interface requirements, etc.

- (U) Integration Testing
  - Build and test specific vehicle integration concepts (Mapping sensors, Countermeasures, and no fire zones etc)
  - Verify software I/O message format is defined as per requirements; communicates with other systems outside of the 'black box' of the subsystem
  - Interfaces/communicates with other 'nodes' on the network
  - Countermeasure Simulators are considered where appropriate for Hardware in the loop validation.
  - Validate specific APS configurations

- (U) Validation Testing
  - Test functional requirements (software latency, etc.)
  - 'Bug' test– validate SW does not lock up/crash/perform incorrectly under various conditions
  - Meet functional requirements
  - Non-functional testing: load/robustness requirements, etc.
  - Validate interoperability with other connected systems

- (U) Not intended to be a physics based model

Example Tasks

Task Name	TRL
LRU Functional Block Diagram	**TRL 4**
LRU Characteristics and Requirements	**TRL 4**
Shake, Rattle, Roll, Speciality Analysis	TRL 5
Architecture, Requirements, CM	TRL4
Insensitive Munitions Tests	**TRL 5**
Insensitive Munitions Board Approval Letter	TRL 6
Fast cook-off	TRL 5
Slow cook-off	TRL 5
Bullet impact	TRL 5
Fragment impact	TRL 5
Sympathetic detonation	TRL 5
Shaped charge	TRL 5
High velocity fragment impact	TRL 5
Counter Measure	**TRL 5**
SMALL ARMS Protection (7.62 Ball)	TRL 5
Environmental Tests	TRL 5
Temperature Envelope	
Temperature Cycling	TRL 5
Sand	TRL 5
Humidity	TRL 5
Salt Spray	TRL 5
Vibration MIL-STD 810	
Fly-Out Counter Measure	
Countermeasure Sensor (seeker)	
Range	
Timing	
Accuracy	
Airframe (SE)	**TRL4**
Safety factors and structural guidance as specified in MIL-M-8856B used for gui	TRL 5
Netting analysis to verify motor case structural design.	TRL 6
Finite element structural analyses to verify airframe integrity for flight testing.	
Modal analyses to determine mode shapes and frequencies. Results used to d	
Aero-elastic flutter analyses to determine flutter boundaries of airfoil surfaces us	
Static motor firings to characterize motor performance, including thrust and pres	
Hydro-burst tests of motor case to insure structural integrity.	
All airframe motor cases hydro-proofed prior to use in flight testing.	
Successful flight of airframe on LTV flights.	TRL6
Successful flight of airframe on BTV flights.	TRL 6
Successful flight of airframe on CTV flights.	TRL 6

Task Name	TRL
Comand and Control Processor	**TRL 5**
Fuze Board Approval Letter	TRL 5
Memory Requirements (ROM)	TRL 5
Conforming Electrical Components	TRL 5
Software Requirements	TRL 5
Environmental	TRL 5
Temperature Envelope	TRL 5
Temperature Cycling	TRL 5
Vibration MIL-STD-810	TRL 6
Temperature Limits (SE)	TRL 6
Noise Factors (SE)	
Anticipated environmental limits/qualifications for each LRU (SE)	TRL 5
Lightning strike requirements (SE)	TRL 5
Convoy limitations (with the same APS systems installed) (SE)	TRL 5
EMI/EMC Requirements	TRL 5
SIL Processor Validation Testing	TRL 5
Search Sensor	**TRL 5**
EMI/EMC	TRL 5
Clutter	TRL 5
FOV	
Resolution	TRL 5
Update Rate	TRL 5
False Alarm Rate	TRL 5
Optical	TRL 5
Sensor Architecture	TRL 5
Vibration (Microphonics, etc.) (SE)	TRL 5
Tracking Sensor	**TRL 5**
EMI/EMC	TRL 5
Clutter	TRL 5
FOV	TRL 6
Resolution	TRL 6
Update Rate	
False Alarm Rate	TRL 5
Optical	TRL 4
Sensor Architecture	**TRL 4**
Environmental Tests	TRL 5
Sensor Validation Testing	TRL 5

Summary

Questions?

Mailbox: DAMI_TARDEC_GSS_AP.C@conus.army.mil